HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: A new UK research funding agency, HC 778

Wednesday 7 October 2020

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Watch the meeting

Members present: Greg Clark (Chair); Aaron Bell; Dawn Butler; Andrew Griffith; Mark Logan; Carol Monaghan; Graham Stringer.

Questions 50 - 99

Witnesses

I: Professor Mariana Mazzucato, Professor in the Economics of Innovation and Public Value, University College London; and Professor Richard Jones, Chair, Materials Physics and Innovation Policy, University of Manchester.

II: Professor Sir Mark Walport, former CEO, UK Research and Innovation (2017-2020); and Jo Johnson, former Minister of State for Universities, Science, Research and Innovation (2016-2018 and July-September 2019).

Examination of Witnesses

Witnesses: Professor Mazzucato and Professor Jones.

Q50 **Chair:** This is the second hearing of the Science and Technology Committee into the proposed creation of a new research agency in the UK, broadly modelled, to quote the Government, "on the US Advanced Research Projects Agency," ARPA, later the Defense Advanced Research Projects Agency, DARPA.

We are delighted to have on our first panel two of the UK's leading and most influential writers and voices on science and innovation policy and industrial strategy: Professor Mariana Mazzucato, professor in THE economics of innovation and public value at University College London; and Professor Richard Jones, who holds the chair in materials physics and innovation policy at the University of Manchester. Thank you very much indeed for joining us this morning.

Perhaps I can start with a basic and obvious question to both witnesses. Do you think the Government are right to be creating the proposed research agency?

Professor Mazzucato: I think it depends. It is absolutely right always to ask whether we have the right innovation system and structures, especially the feedback effect between the structures.

The big question the Government are asking themselves is whether there is a gap, especially in being able to take high-risk big bets in an area that is important for the country around challenge-based thinking and creating dynamic linkages between basic and applied, which is different from, say, what the Catapults have been set up to do.

For that high-risk basic R&D, which is guided by mission-oriented thinking, there is currently a gap in the UK, and ARPA could potentially fill it. When I say "maybe" and "it depends", it really depends on how it is designed. I am sure the Committee is after that question.

One of the key features—stop me if this will come up later—in the US with the ARPA system is how it is connected to different parts of government. If we end up creating an ARPA in the UK that is not connected to different systems, or aligned to what the Government's big objectives are, it is not going to be very useful. As an example, it has to be connected to procurement policy. The word "procurement" means that you actually want and need something, so the first question is what we need and want for the UK and making sure that our innovation system is aligned to help to deliver that, but just creating a castle in the desert is not going to work.

Q51 **Chair:** As you anticipate, we are going to come on to some detailed questions around its design and structure.

Perhaps I can pose the same question to Professor Jones. Are the Government right to be contemplating this?

Professor Jones: We talk about the need for risk taking in research, and we need to be a bit innovative and risk taking in the way we fund research. It is worth being experimental about trying some different things. Pluralism is a virtue, so having different approaches is good, too. In principle, I do not think there is anything wrong, as a starting point, in thinking about whether we can try to do something slightly different and looking at models overseas.

Q52 **Chair:** You both referred to a problem, to which ARPA may be the answer, which is to take greater risk and be prepared to do things that other institutions would not. Sticking with Professor Jones, given the profusion of our very highly regarded universities and non-university institutions, like the Crick Institute and Turing Institute, why do we not have the solution to that problem already in the system?

Professor Jones: It depends what problem you think there is. There are multiple goals that a research system needs to try to solve. A research system needs to have something to support fundamental disciplinary research. Our research councils do that. It needs to have something that supports interdisciplinary research better. In principle, UKRI should do that; it is perhaps too early to see whether it is able to deliver it. We should be able to support innovation in businesses. We have Innovate UK and the Catapult centres to do that.

The question of what you are missing is trying to find solutions to problems of the Government that they do not know how to go about solving.

As for where I would look for a gap, I think it is connected, as Mariana said, to the question of procurement and what the Government want—not now but in 10 or 20 years' time. That will not necessarily come without prompting from either the academic community or industrialists who need to make a profit next year, or at least over the next few years.

Q53 **Chair:** I am struck by what you said about things the Government want and may need. Do you regard that as being crucial to its remit? As you know, in science policy the Haldane principle suggests that researchers should determine what they research. Do you think this should be anticipating what Government needs?

Professor Jones: Yes. We could have a diversion into what the Haldane principle actually says. The Haldane principle says that researchers are in the best position to determine individual funding decisions. The original Haldane report of 1917 or 1918 talked about very pressing problems that the Government had at the time in fighting the war against Germany, the need to understand the toxicity of TNT and how to preserve fish.

I do not think there is any problem in the Government setting strategic goals. Perhaps I should not even say "the Government". This is a question about the state's long-term strategic goals. It is not really about what the Government want right now and things that meet some passing

trend or fashion; it is about taking a long-term view about what the state and nation will need over periods of decades.

Q54 **Chair:** Professor Mazzucato, do you share Professor Jones's view on what problem or problems ARPA should be geared to resolving?

Professor Mazzucato: Yes. I would add that when you, Chair, were a Minister in BEIS you did something quite extraordinary and very helpful for the country. In a way, that should be the backdrop to this discussion. You transformed the industrial strategy from being sector focused, which it had been—there is a list of top sectors from automotive, aerospace, financial services, creative industries and life sciences—to being challenge oriented, getting all the different sectors across the economy to innovate, invest and solve key societal challenges.

I have here your wonderful report. You chose four challenges: clean growth; ageing; the future of mobility; and AI and the data economy. As you know, Lord Willetts and I then co-chaired a commission for mission-oriented innovation that could help you to think of moonshots and missions underneath those different challenges.

That is kind of what we are talking about here. That is not going to happen on its own. You need agencies that oversee those missions.

We should remember that the moonshot, the 50th anniversary of which we celebrated last year, required lots of innovation across many different sectors. It was not just aeronautics; it required lots of innovation in nutrition, textiles, materials and electronics. The whole software industry occurred as a spillover of that. That required both basic research and applied research, so that is really a false dichotomy.

Inside DARPA, as with ARPA-E today and the discussions of an ARPA-H in the United States, you would have both basic and applied, but this would be a new kind of institution in the UK where those cross-sectoral and cross-departmental discussions inside the UK Government would occur based on key challenges, like the future of mobility and lots of different types of innovations that could be inspired by that. Currently, there really is not an institution that oversees that.

In some ways, if you are to have a challenge and mission-based industrial strategy, currently the industrial strategy challenge funds are dispersed and do not really have leadership. The key possibility here is to allow an ARPA in the UK in different areas—health and energy—and not just the Ministry of Defence, to lead on that mission-oriented thinking, linked up with the other institutions. Currently, there is not an agency that can oversee this challenge-based approach.

Q55 **Mark Logan:** My questions will be slightly related to where you were going with Greg just now. What do you feel should be the purpose of UK ARPA?

Professor Mazzucato: This is going to be a huge debate. Personally, my answer would be that you need different ARPAs, potentially. You would need an ARPA perhaps more focused on the health challenges. When I say "inter-sectoral", that would also apply around health. A cancer mission, for example, is not going to be just about pharmaceuticals; it would include all sorts of innovation that are required for those who survive cancer, or preventive solutions that we need so people do not get it.

Therefore, around energy, defence and health, I believe it would make sense to have ARPAs for those broad areas. The key issue then is how you get Government instruments like grants, loans, procurement and prize schemes to interact with that ARPA to galvanise and catalyse those bottom-up solutions that will be required to fulfil the missions themselves.

Currently we are engaging with this discussion in the United States arguing for an ARPA-H. Currently, in the United States you have DARPA, which is in the Department of Defense, and you have ARPA-E, which is in the Department of Energy. In a strange way, there has not been an ARPA-H, even though the US Government spend $40 billion a year on health innovation. Because there has not been an ARPA-H, the net funding has often been both too disperse but sometimes has created a problematic public-private partnership.

What is really interesting about DARPA and ARPA-E, and what would be incredibly useful in the United Kingdom, would be a much more symbiotic and mutualistic public-private partnership, which we do not have in the health area, where the prices of the drugs or the governance of the patent system often are not working in the public interest, even though there is all that public funding.

If you look at how DARPA has negotiated prices and contracts with the private sector, you see it has been much more ambitious than that. Therefore, part of it is also to design a new public-private ecosystem, as opposed to just talking about the basic research that is needed in different high-risk areas.

Q56 **Mark Logan:** I am reminded that, at the Edinburgh Festival a number of years ago, the former chairman of Google criticised the UK in particular because he felt that, across industry and academia, people were working in silos. Do you see that as a greater problem in the UK than in the United States, or is it a problem that we share across countries?

Professor Mazzucato: First, all countries are going through enormous change. For example, China is learning what the US did very well in the past, at the same time as the US is unlearning that at the current moment in its history. If we look at the past US funding of innovation, I would argue that it was definitely very cross-sectoral and quite intradepartmental in the ways I just discussed.

My experience is that that is a bit of a weakness in the UK. For example, for the small business innovation research programme in the United States each departmental budget sets aside between 2.5% and 3% for procuring innovation by small and medium enterprises. The same scheme in the UK, SBRI, has been less successful because it has not been as linked up to that cross-departmental procurement strategy.

That comes back to what the Government actually want to do. What are their ambitions in other technological areas, but especially in these challenge-oriented areas—health systems, the digitisation agenda and climate change?

Climate change is a very broad challenge. You could formulate interesting cross-sectoral and cross-departmental missions around that, but that would require the Government to be able not to work in silos across those Departments. Having said that, most countries have departmental silos, so do not feel too bad about that.

Professor Jones: If we look at ARPA and its great successes, we see there is something very specific about the demands. For example, the demand would be that the armed forces want to have a method of knowing where they are anywhere in the world to high precision. The result was the global positioning system and its fantastic spillovers to civilian life. It wanted to have an aircraft that would be reflective to radar. The result was the invention of stealth technology, with fewer spillovers to civilian life but very important militarily.

There is something about defining a need quite specifically. At that point one needs to get academia together, because, if the need is far enough ahead and the technology is not yet in existence, that needs to draw in the academic world to find key advances to make that happen; and it needs to involve industry, because industry has the scale to deliver projects like that.

I want to emphasise the business about delivering something. The moonshot was an engineering project. You knew when it had happened because we got to the moon and back. Arguably, the real moonshot of the ’60s in the United States was the project to be able to deliver half a tonne of stuff to within a few hundred metres when you were on the Earth’s surface. The first mass-produced integrated circuit-based computers were the guidance systems for Minuteman missiles.

One needs something that is specifically important to the Government. In that case, it was the armed forces, but it could be healthcare professionals in a health version of ARPA, or the people who have to run the electricity system for an energy version of ARPA. There needs to be somebody with an engineering problem too difficult to solve right now, but this will solve it and it will be delivered. I stress that is why I think ARPA has been successful in the places where it has been successful.

Q57 **Mark Logan:** Given the United States’ historical experience of DARPA

being arguably the big success story, should we be looking at something that has a greater defence focus? We heard from witnesses from DARPA a couple of weeks ago. They said their singular focus was on producing things that helped with defence, and anything that was ancillary to that was just an upshot or a good chance. What are your views on that? Should we be focusing on defence?

Professor Jones: We should focus on something. There is more than one possible focus, but having a customer in the form of generals who think that, if you do not deliver this, their soldiers will be put in harm's way is a tremendous focus.

It is not the only one. I think security is important; energy is really important. The transition to net zero 2050 is a massive shift of the whole economy. We should appreciate what a big deal that is. There are huge challenges in healthcare, too.

The key point is that it needs to be focused and have a customer, if you like, and we need to make sure those foci are aligned with what the nation and the state really think they need.

Professor Mazzucato: I agree with Richard. I wrote a whole book about specific questions, like getting satellites to communicate, which is why we ended up with the internet. These very specific questions that were urgent and, as you say, often had a military focus produced some of the biggest innovations of our time: general purpose technologies like the internet and GPS. Everything in our iPhone that makes it smart, from Siri, voice-activated systems and the touchscreen display, to driverless cars today, came about from questions being asked and solutions that were required. Luckily, they were not micromanaged, because that would stifle innovation. It is absolutely true that specific problems that stimulate bottom-up innovations are key to the DARPA success.

If we ask who was driving that success within DARPA and why all these great scientists were even interested in working within these organisations, it comes back to the big, broader questions. For example, I would argue that the reason a Nobel prize-winning physicist, Steve Chu, was willing to become a civil servant and direct the Department of Energy and then set up ARPA-E, which was run by another great scientist, Arun Majumdar, was the idea behind the Department of Energy at that time.

This was post the financial crisis with the very large fiscal stimulus programme of about $800 billion. Obama had been talking about directing the fiscal stimulus in a green direction, again focusing on the big challenges of our time, climate probably being the largest. It was a real honour for a Nobel prize-winning physicist to come in and work with Obama to help not just de-risk the private sector, or fix market failure, because that is not very exciting, but take risks and set up organisations that would help, alongside others, fuel investment and innovation towards that goal.

As for the specifics of how you then make ARPA-E or DARPA successful, I am sure that at your previous hearing some of the people from DARPA talked about the specifics of organisational culture, et cetera, but the big picture about what the Government and the civil service are for, and why you even need to focus on big problems and not just think you are there to create an indirect incentive for the private sector to innovate, is historically what made it really exciting to work inside these institutions, and that is not independent of their success.

Q58 **Chair:** Professor Jones, do you have a view on who decides the focus of ARPA? Should it be given a remit, or should the first task of the organisation be to choose one for itself?

Professor Jones: I do not think the organisation should choose its own remit. What is needed is some long thinking by Government. The Nurse review talked about a ministerial Cabinet committee, did it not?

Connected to this, one needs to think about the mechanism by which the Government set long-term technological goals. The Government Office for Science is possibly the sort of body that could co-ordinate that, but it would need to have lots more serious input from different Departments. One needs to get out of those silos in Government. I am unashamed in saying that I think there is a place for Government to set big strategic goals. It should be a wider discussion with many people feeding into it, but one of the roles of Government is to decide what they want, is it not?

Q59 **Graham Stringer:** Professor Jones, you gave a very vivid description of how DARPA has worked and why it has been successful in the clear client's eye from the military on what it needed.

I am becoming convinced, having read the submissions and listened to the oral evidence, that there is no real equivalent in the rest of Government or society to the model that the Americans use to innovate with their military. Why am I going down the wrong track, or am I right?

Professor Jones: You are right. It was a particular time and place, was it not? The cold war was a particular set of circumstances that made technological innovation enormously urgent. It is important in thinking about DARPA to understand that it was part of a much, much bigger system, and still is. DARPA's budget is pretty small compared with the overall research budget of the US military.

We talk about ecosystems. We have to think about DARPA. Part of the reason for its success was that it sat as part of a much bigger ecosystem that encompassed a lot of very directed applied research, supported directly by the Department of Defense, and a lot of very basic research supported by the NSF and the Department of Defense. I am a physicist. US academic physics was pretty much kept afloat by organisations like the Army, Air Force and Office of Naval Research in the '50s and '60s, so there was huge support across the whole spectrum.

A huge private sector R&D effort supported it, too. People do not quite appreciate how big the US private R&D sector is and how much that is directly supported by the US Government. More than 50% of R&D directly carried out in the US aerospace industry currently—*[Inaudible.]* There was that combination of utter focus. The cold war was an existential period; the very existence of the nation was under threat and huge resources were thrown at that, and ARPA was part of that picture.

Q60 **Graham Stringer:** I agree. I think it reinforces it, if you look at what in this country an energy ARPA would look like. You are a physicist. If you had an energy ARPA, you would be fighting two things: how to get the equivalent energy density in hydrocarbons and looking for the equivalent client side of the Department of Defense in the States. It is difficult to see how that would work. It might be more sensible to throw a lot of money at hydrogen fuel cells, for instance, if you want to deal with energy. Professor Mazzucato is shaking her head violently.

Professor Jones: Those are the challenges you could imagine. I have my own views, and you would want to take other views. If you want to have long-haul flying in 2050, you will need to work out how to do direct air-capture of carbon dioxide and make hydrogen in a low-carbon way, possibly from high-temperature fission reactors.

You can get different opinions about the different technological approaches, but that is the challenge, is it not? If you think it is important to have long-haul flights with zero carbon in 2050, you will have to make synthetic hydrocarbons. That is my view; others will have a different one. Those are big challenges that would deliver engineering solutions and big spillovers. Those are the sorts of things you might want to think about.

Professor Mazzucato: The question about defence is an important one. You are right that, in the past, it was mainly through military and space funding that DARPA and NASA arose. Of course, NASA was set up at a very similar time to DARPA, and they worked together in different ways. Defence and the cold war very much defined the missions, the urgencies and the security problems being faced in the ’60s and ’70s.

Today, the climate crisis is one of the most urgent problems we have. What would it look like to have an ARPA focused on climate? I do not think it should just pick pet projects, whether it is around hydrogen or nuclear fusion. The reason I speak with an American accent but am Italian is that my father went to Princeton University when I was very young to do nuclear fusion, all funded by the Department of Energy, as most basic research is funded in the United States around these kinds of big public good areas.

The question is: what can we learn from that period? The very important question is what we can learn from a period when it was mainly defence questions—cold war questions—that drove these mission-oriented agencies like DARPA. How can we apply them, not in a cut-and-paste way

but still learn the lessons around some of the great societal challenges we have today?

The sustainable development goals were agreed on by so many different countries, including the UK. We have signed that charter. We need to be thinking about how those goals and challenges, especially climate, which poses a security risk for the planet, can learn from the DARPA model.

That portfolio perspective, which was and continues to be so important inside DARPA—not putting all its eggs in one basket but turning the tap on across different areas within a portfolio, again focusing on a very particular problem—is itself a very important lesson. That means a wide risk distribution across that portfolio, but also knowing when to turn off the tap. DARPA has been good at funding but also knowing when to stop funding, and that flexible, adaptable internal organisational culture will be very important if we are to set up one that is going to be focused on the key problems of today.

Q61 **Graham Stringer:** My final question is a very specific one to Professor Jones, looking through the other end of the telescope. Manchester University is the basis of graphene. Professors Geim and Novoselov were critical of the way money was given to the Graphene Centre. I think one said it just went into bricks and mortar and not real scientific research. That was a great UK breakthrough in materials science. Is there anything that can be learned from the successes and failures of that and fed into the future structure of a DARPA organisation? And is £800 million enough?

Professor Jones: To deal with the second question about £800 million, it comes back to thinking about scale. What is the right scale given the overall effort of the UK's science investment? Currently, the UK Government spend about £12 billion on science directly, and probably a bit more than £4 billion indirectly through R&D tax credits, which are a very large subsidy to industrial R&D.

The question is: what is the right scale? The numbers people have talked about for a UK ARPA feel about right in the relative scale compared with the rest of the overall enterprise, set in the context of how big US ARPA is compared with overall Government R&D spending. That is important.

Q62 **Graham Stringer:** What about graphene?

Professor Jones: On graphene, 2D materials are fantastic scientifically and the results are still coming in. For example, if you sit on panels looking at proposals coming in, some of the most marvellous things involving 2D materials are being proposed. It is a fantastically rich area of physics.

People want a function rather than a material, so it is not necessarily always right to ask, "What can we do to commercialise a particular thing?" What you want to ask is, "I have a particular problem I need to solve. What can I use to address that?"

Maybe I should go back to an earlier example and something in which I am still professionally involved as a physicist. The UK was a very early leader in the area of plastic electronics, and some great discoveries were made in Cambridge. Some good companies were set up in Cambridge, but ultimately the industry went to the far east and it lives in Korea. That illustrates the fact that a single technology or material is generally not enough by itself. To make a display on a mobile phone you need to bring together a huge number of different technologies. You need lots of companies coming together, and you need to think about whole supply chains and clusters where there is lot of reinforcing expertise. An iPhone display has glass; if it has liquid crystal, it has liquid crystal materials; it has colour filters. There is a whole bunch of quite complicated detail and bits of technology that have to go in there together.

In places like Korea, which in a way cornered that market, there were many different companies all contributing a little bit to the problem. Therefore, how you build up those industrial clusters to take advantage of technologies is one of the crucial things we should think about.

Professor Mazzucato: One thing that Korea and other countries have that has weakened the UK, coming back to the issue of ARPA working within a system, is long-term patient finance. For example, the US has one of the largest public venture capital funds in the world. It is funded by the CIA and is called In-Q-Tel. Israel would not be a start-up nation without Yozma, a public venture capital fund. Korea has had lots of long-term patient finance. Looking at DARPA working within a system, patient finance was very important to allowing those few companies that were willing and able to innovate, using the technologies being produced, to have the time to learn and innovate alongside DARPA. I think that whole issue of patient finance, and the lack of it in the UK, should be looked at as part of the gap we need to fill alongside an ARPA.

Q63 **Carol Monaghan:** Professor Jones, you have talked about the space race in the US. That is probably a very good example of a focused goal. We know we are good at working to targets. Is there a difficulty that the target could be dependent on the pet project of the particular person or team involved in funding? Some might say that climate change is the most important thing; others might say it is Covid and global pandemics. I will throw in another "C". Others might refer to China as something we should be looking out for. How do we decide what is the most important issue?

Professor Jones: I think it is a fascinating question. We should distinguish between two things: the big strategic problem—in a sense, in the American analogy the biggest strategic problem was the cold war—and the specific goals you might need, and inventing GPS was part of that.

It is part of politics and political discourse that we come up with a societal consensus about what the big problems are. That is a discussion in which politicians have a very big role. Political discourse is really important in

getting a sense of national unity. Many different stakeholders agree, and I think Mariana and I are absolutely agreed. From my perspective, I think climate change is a massive one. Getting to net zero by 2050 is a great target. I am impressed that politicians have signed up to such a hard and important target.

Having got a consensus about the big goal, we need to have a national discussion about the way you do that. Within that, you need to get specific goals.

This comes back to risk taking. One of the features of DARPA's success is that it had programme leaders, and the very successful ones were in their own ways quite individual visionaries. They had their own vision about how some problem should be solved. I believe Licklider was the programme leader who was instrumental in all the early computer networking in the '60s from which much of the internet architecture came. He was a man with a very strong vision about how he thought the problem ought to be solved, and he then had the freedom to do it.

On the one hand, you need a big societal consensus about what the big problems to be solved are, and then you need to empower people to try out different approaches that will deliver some aspect of the solution.

To go back to what I said right at the beginning, this is an experimental risk-taking business and some of them will not work.

Professor Mazzucato: The UK set itself the challenge through a political process. Greg Clark's team was in discussion with the Government to come up with the four big problems for the UK economy: ageing, clean growth, future mobility, AI and the data economy. That is the backdrop. The question is: is it even possible for an innovation system to focus on those broad four challenges, which must be, as Richard said, decided politically? The green deal, for example, is not going to be decided by a pet project—that is the broad agenda.

You then need organisations that are able to catalyse the innovation that is required to fulfil that promise. As Richard was saying, the whole point of DARPA was that it had contracts with programme managers, with a very robust system of scrutiny, who were allowed to pursue pretty specific areas and bring in great teams to do that successfully. A key reason for its success was that it was separated from political scrutiny and allowed to take risks.

You need both. You need the broad challenges, but you need an agency that is able to put full might and risk taking to—

Q64 **Carol Monaghan:** Is there a danger, if you are talking about risk taking, that we are too driven by very short-term impacts? For example, academics are used to things like the REF and TEF, writing papers, and bidding for funding. In industry, it is probably a bit different. If we are looking for quick impacts, are we pulling the rug from under our feet?

Are we potentially spreading ourselves too thin with the money that is available if a lot of different groups are scrabbling for what is available?

Professor Mazzucato: It is not one or the other. UK ARPA is not supposed to replace conventional science funding. We often come back to that false dichotomy of basic research, applied research or challenge orientation. A healthy science system—an innovation system—will have basic research and applied research. Organisations like the Catapults, the Fraunhofers or the NISTs in the US facilitate communication between basic and applied. What we are talking about here are particular institutions that will be going after some key, specific problems that are connected to the challenges that the country is facing. There has to be a very healthy discussion between those, as opposed to thinking that this is going to replace much more long-term blue-sky thinking.

The DARPA model was not that short term. A five-year term for people to come in through a secondment programme—usually, not always—and to stay in during those five years and be told to take risks around these big, bold projects is different from the short-termism that you might have in the political process driven by elections.

Professor Jones: There is a spectrum. There is a place for short-term projects. It is important. Companies need to get products out. Companies have problems that need to be solved. Rolls-Royce needs to work out how to put a coating on its fan blades so that it can run its engines a bit hotter. These are good projects that are absolutely mainstream applied science, applied R&D, on which industry and academia should be working together with some support from, and often in partnership with, Government funding agencies like Innovate UK and industry itself. That is the important part.

Academics should be free to go and do absolutely wacky long-term things. As you know, Andre Geim is a fantastic example that Graham mentioned. Nobody could have predicted the very unexpected and totally unpredicted, weird behaviour of electrons in 2D materials, and nobody would know what the applications of those might turn out to be.

It is getting that balance right. My view is that ARPA should be in that place, which is both long term but with a focus. It should not be about the next REF cycle or even the next quarterly profits reading. It should be about something long term, but it should also be a concrete goal. It is important that we have scientists who are unconstrained, trying things out to see what happens to find out these unexpected new discoveries that can be quite transformational.

It is about looking across the whole system, seeing what the right balance is between those different elements.

Q65 **Chair:** Both of you are saying that, before ARPA is set up and gets under way, there needs to be a political or, one might say, a national conversation about its priorities or mission. Is that right? Would that be a

fair characterisation?

Professor Jones: I do not think I would necessarily say you had to wait. If you decided you wanted to do an experimental funding agency in this area, it takes time to get stuff set up. You should get on and get going.

Professor Mazzucato: If you have a strong political will, for example, to achieve carbon neutrality over the next 10 years across different parts of the UK, that can be a real stimulus for innovation that an organisation like DARPA would then independently—it would not be subject to the political process—use to guide a lot of its thinking. That is what is occurring right now in the US. A lot of the innovation that has occurred around battery storage occurred inside ARPA-E, and that is driven by a green agenda. That is very different from micromanaging that agency, which would stifle the innovation.

A combination of top-down agenda setting and bottom-up innovation around concrete, very specific questions that then stimulate a lot of innovation is the balance that you need to get right. That is currently a big question for the UK: do we hear enough about the agenda around sustainability that could guide the innovation system itself? I hate to say it, but I think the answer is no.

Q66 **Andrew Griffith:** I believe Einstein's definition of madness was doing the same thing again and again and expecting a different result. I am interested, given we are reaching alignment on the objectives for ARPA, in some of the more structural aspects—in particular, how disruptive you would coach us to be both in its governance and in its sponsorship. If I throw a few questions, it will give you both a chance to pick them off.

Should it sit within the conventional research and innovation establishment—under UKRI, for example—or in parallel with that? Where would you look for it to get sponsorship from? Should this sit within an existing Department, accepting that we know—you have both had experience of working with Government—that they can be quite vertically siloed? I believe this Government have an ambition to change some of that. As you saw with Greg's cross-cutting work on the grand challenges, that takes an enormous amount of constant effort, in my experience, to continue to focus.

Would you caveat that an ARPA should sit outside that system, perhaps in the Cabinet Office or No. 10? I am interested in your institutional observations about its ways of working and how you set it up for success, because we can probably all agree that setting this up, giving it a huge challenge, and then not giving it the right ingredients to achieve that is a waste of time and money.

Professor Mazzucato: I have recently been advising the European Commission on exactly that question. I wrote a report for them around the concept of needing to think about the ARPA model and, specifically,

the need for mission-oriented innovation to be a new way to think of the vertical, not so much the horizontal, challenges that Europe faces.

The report that I wrote successfully created a missions instrument, but it was housed within a specific part of the European Commission that is the DG for Research and Innovation. It was called DG RTD at the time, and it was being run by Carlos Moedas.

I started to feel exactly the problem that you have just outlined for the UK: that sitting in the Ministry of Innovation was not the missions instrument, being inspired by the functions and dynamism that DARPA had. It was too siloed even there. It really needed to sit above the DGs if it was going to be useful for Europe to steer the region towards achieving specific goals, precisely because it had to align different areas from health, DG Connect, DG Transport to DG Innovation.

The same question for a national Government is that, if the DARPA model is about stimulating innovations around these broad challenges but in the specific ways we have been talking about around concrete problems, it is going to be much more successful if it is able to stimulate as much cross-departmental, inside the Government, and cross-sectoral, inside the private sector, innovation and investment.

I would agree that, ideally, even the challenge teams that Greg Clark set up to have a challenge-oriented industrial strategy should be sitting above BEIS, for example. The Cabinet Office could be an interesting place to consider where to house a UK ARPA. The other possibility, as I mentioned at the beginning, might be to have ARPAs in the Ministry of Defence, in the Department of Health and in the Department of Energy, but to make sure they are designed in such a way as to inspire cross-sectoral and cross-departmental conversations. Having more than one could also facilitate that.

Professor Jones: Let me start by saying I do not necessarily feel that the machinery of government is my specialist subject. I would also make the observation that UKRI is quite a new organisation itself. In an ideal world, there are reasons why you might want to have it in UKRI because you would want to have it connected to the research councils and Innovate UK. The question is whether we think that UKRI is a mature enough organisation to be able to operate in a risk-taking way.

There is an interesting thing about risk here. We accept a lot more risk in science funding than we do in innovation funding. Bluntly, that is because nobody really understands science. Scientists make all kinds of mistakes and nobody really notices. They go down blind alleys and wrong turns, and nobody notices. There are big political penalties for getting an innovation project wrong, as I think the Government are starting to see in some other areas, because it is much more visible. If you have a moonshot and the moonshot does not actually land on the moon, everybody notices it. A Minister can get very upset about that.

The argument for UKRI is that it is set at a bit of a distance and someone else can take the blame for the inevitable things that will go wrong if you really do deliver. If you do the risk taking that you say you want to do, you will make mistakes, which may cause political embarrassment, so there is a reason for wanting to separate it. I am just speculating. I could not possibly understand how Ministers actually consider these matters.

In terms of where it sits in Government, the history of this is long and I have not looked at it in advance. My memory of it is that science, in Waldegrave's time, lived in the Cabinet Office. It then moved to the Department for Innovation, Universities and Skills. That was then merged with DTI with the return of Peter Mandelson. That was then turned into BEIS in the coalition. BEIS then accumulated DECC in the 2015 Government.

There are lots of machinery of government changes around where science sits. In a sense, we have tried lots of things and, to be honest, I am not really sure it makes that much difference. Other people are better qualified to say that than I am.

The argument in principle for it being a cross-Government thing is important. I regret that the recommendation in the Nurse review for a ministerial-level committee essentially to be what you could think of as the ministerial sponsor of Government Office for Science was not acted upon. You could imagine a structure that had a ministerial committee, a Government Office for Science that was able to do the strategic work to sort out what science ought to be funded, and then UKRI being associated with that. At some point, I am going to say I am just a physicist.

Q67 **Andrew Griffith:** For someone who said you were not that sure about where science sits, you gave an uncannily accurate description of its various travails around Whitehall.

The thing I am trying to reconcile in my mind—it may bridge us to the next witnesses—is how we reconcile the degree of Sputnik-type ambition with things like pulling Permanent Secretaries in front of Select Committees and the National Audit Office's scope, which quite rightly has an agenda that is inimical to taking those very abstract risks. Perhaps we will continue to focus on that.

Professor Mazzucato: The head of DARPA does that constantly. They have to defend their budget. They go in front of the Appropriations Committee. They talk about why the institution is critical for some key national goals. That is not so much the question. It comes down a lot to what Richard was talking about, which is, if along the way you are going to mess up quite a bit—that is normal: trial and error and error and error—how do you make that part of the remit itself? That comes back to the risk taking, but it is not risk taking for the sake of taking risks; it is to solve key national priorities.

A lot of the mistakes, as Richard said, become publicly known, but a lot of the successes are unfortunately then seen as private sector successes. I often give the example of the US Government having the portfolio it did post crisis where they helped both Solyndra and Tesla. Everyone knows about the Solyndra loss—it became a whole national debate about picking winners—but very few people realise that Tesla received a $500 million guaranteed loan from the US Government and the Department of Energy.

We need the ability to narrate to citizens that it will be normal to fail along the way in making these bets, because there is quite a bit of ideology in the background. This is not really the place to go into that.

Q68 **Aaron Bell:** My colleague Andrew Griffith has just talked about the overall research and innovation system, and we have had competing submissions, including from Professor Jones, about where ARPA should sit. If we assume that it will sit outside UKRI—that seems to be the stated intention of the Government—how do you think an ARPA's structure should operate organisationally? Should it broadly replicate what DARPA does—the programme managers and its organisational culture, which is very lean and flat? Is that the best model for us to follow?

Professor Jones: I think that is right. It is worth doing that because it is different. We have science funding that is based on scientists submitting projects. We have science funding based on brilliant individuals. The distinctive feature of ARPA, from a science policy point of view, is that it is based on the vision of programme leaders. If you are going to do it, you should do it around the vision of programme leaders.

That means a very lean structure. The major job of the director will be to recruit the programme leaders. It will be a hard job to find them. They will be enormously high-calibre people, and probably enormously successful in academia or industry, or preferably both. If you are going to do this, that would be the model one should take.

Professor Mazzucato: The key characteristics that are always useful to repeat to oneself—because otherwise we forget—are: having organisational flexibility is absolutely key; it is flexible and independent from branches of Government; a flat internal structure; being able to hire outside standard Government recruitment processes; five-year fixed term employment of directors and project managers, who are told to take risks; flexible contracting mechanisms; and having a bottom-up programme design to inspire as much innovation to solve the concrete problems that we have been talking about. Discretion in project choice and very active project management by the visionary leaders will also build teams that are as able as possible.

The way in which both DARPA and NASA procured and contracted with the private sector is also, as I mentioned before, a very important lesson. Bringing in the private sector along the way to solve the problems but to be focused on solving those problems as opposed to simply being driven by the need to commercialise and bring some private sector initiative into

an area without then being clear of the big goal is an important lesson. They experimented with lots of different types of contracts.

Q69 **Aaron Bell:** Assuming we have a generalised mission, whether it is health, energy or whatever it might be, for our DARPA or DARPAs, how should the projects that they then embark on be decided? How open and transparent should that process be? Who is going to be pitching these projects and then selecting the programme managers for them? How would you see that working, Professor Mazzucato?

Professor Mazzucato: This comes back to the previous question. The director should, in fact, be reporting directly to a Minister and be in constant conversation. I recommend you read a wonderful book called "Inside NASA". NASA in its heyday had a lot of the features I mentioned about DARPA. There was a constant discussion with the equivalent of the Secretary of State here, even though they were independent of the Secretary of State or the Ministers in charge.

The decisions occur through a portfolio perspective, driven by the vision of the leader and the team itself. It comes back to the issue of the difference between a broad challenge—as climate change or the cold war were—to specific missions that the visionary leader of the DARPA or ARPA institution would be setting. That portfolio approach means that it would not just be one pet project. It would be different projects that would be driven by the DARPA director.

Professor Jones: I broadly agree. We hear a lot about the need to reduce bureaucracy. If that is the goal, you probably would not have a very transparent process. It probably would be down to the director consulting with ministerial colleagues.

Q70 **Dawn Butler:** I was not here for the first session, so this is all new to me and it has been very interesting. You have answered my question regarding what the key drivers should be. It makes more sense that programme leaders of the highest calibre and experience are the key drivers of ARPA. I am struggling a little to understand the difference between ARPA and UKRI. If UKRI is very new, I do not see why ARPA cannot be a part of UKRI. I am still struggling with why we need ARPA.

Professor Mazzucato: You are absolutely right to ask that question, and it comes back to why we have to keep changing names of existing institutions or set up new ones and what the real gap is. That is why it was really helpful that we began this session talking about where the problems are in the innovation system and how an ARPA-type institution might help solve that.

We talked about the fact that one of the key gaps was the lack of challenge orientation and mission orientation within the innovation system. The UKRI does not currently see itself as having been set up to do that. Maybe it could evolve to do that and ARPA could sit inside UKRI—we should not say that that definitely should not be the case—but

having an organisation that sits above this innovation system, which helps it to communicate directly with key Government goals, and a programme-specific structure but still in direct conversation with the key challenges that the UK economy and society are facing, does not currently exist.

Why not experiment with that and give it as much freedom as possible, while being as connected as possible with the other bits of the system? If we do not connect it with the other parts of the system, I do not think it will work.

Professor Jones: It is too early to see what kind of organisation UKRI is because it is still young. An organisation that could accommodate ARPA would need to be one that accommodated pluralism. It would need to be very responsive and flexible. I hope that is the organisation that UKRI is developing towards.

Chair: Thank you very much indeed, Professor Mazzucato and Professor Jones. We are very grateful for the help you have given to the Committee both in your evidence today—which has been wide-ranging and clear—and in the written submissions that you have given to the Committee and your writings around this area, which you have devoted a lot of time to thinking about over a considerable period. We will reflect on what you have said today and your written submissions when it comes to making recommendations to the Government through our report. Thank you for joining us.

Examination of Witnesses

Witnesses: Professor Sir Mark Walport and Jo Johnson.

Q71 **Chair:** I welcome our second panel of witnesses, which comprises two people who have been responsible for creating and running the current institutions of UK research funding.

It is very good to see Jo Johnson back in Parliament, if virtually. He was Minister of State for Universities, Science, Research and Innovation in the Cameron, May and Johnson Governments. As such, he took the Higher Education and Research Act 2017 through Parliament as a Bill. That Act created UK Research and Innovation. It should be obvious from the CV I have just described that Jo and I were colleagues in the same Department when I was Secretary of State at BEIS. I should put that on the record and declare that to the Committee.

I am also pleased to welcome Sir Mark Walport, who was the inaugural chief executive of UKRI and served in that position from 2017 until just a few weeks ago. Thank you both for contributing to the Committee's inquiry.

Perhaps I can begin by asking Jo Johnson and Sir Mark Walport the question that I asked the previous witnesses. Are the Government right to be creating a DARPA?

Professor Sir Mark Walport: Thank you very much, indeed, Chairman. I found the discussion about ARPA rather curious because I have always been taught that form should follow function, yet we are having a discussion about a form—ARPA—without actually being clear on what its function is, which is critical.

There is a danger that this is a surrogate discussion to find a push solution to a problem of pull. As your previous witnesses made absolutely clear, the great success of DARPA was that it had a very strong customer from day zero—the American Department of Defense. Of course, it was created in direct response to the launch of Sputnik 1 in October 1957.

The critical question is the extent to which Government and others are willing to procure the advanced research and innovation they need to tackle big problems. Of course, there is a paradox, in a way, because there was discussion in the last session about an ARPA for health. Around the world, for fairly obvious reasons, the defence establishment has always procured its R&D. It has to do so because it cannot buy the most advanced technologies off the shelf.

It is slightly odd that health, which is very obviously a public good, has been left to the market. We have seen a chronic challenge in the UK of a lack of very good procurement by Government. SBRI was raised as a model that works reasonably well in the United States, but it has not worked terribly well here because there is no well-embedded philosophy of procuring innovation.

For an ARPA to work, it needs an environment where the products of innovation are sought, procured and, as Richard Jones or Mariana said, there needs to be a long time horizon for doing it. It is about procuring problems in the future. It is slightly odd, in a way, that we are going to have an ARPA without working out in advance what it is going to do.

My second introductory comment goes to the question about UKRI or not. It is not true, as Mariana said, that UKRI has not been formed with challenges in mind. As you know yourself, the industrial strategy challenge fund was a completely new form of funding that UKRI took on from the very beginning and has a number of ARPA-like features and a number of lessons to learn from it. For example, the Faraday challenge, which is to develop the battery storage that we need for the future, is a very ARPA-E-like challenge. The Prime Minister made an announcement recently at the Conservative party conference about the UK becoming world leading in wind power. That works only if we have very good storage, because wind is an intermittent source of power.

There are a number of learnings from the industrial strategy challenge fund. We appointed challenge directors very much based on the model of DARPA. It is worth saying that one of the features of DARPA challenge directors is that they are extremely well paid, which has not proved possible with challenge directors for the industrial strategy challenge fund.

They have had a lot of freedom. If you spoke to some of the challenge directors, you would find that one of their frustrations is that they have not had that degree of freedom in being able to run their programmes.

The critical question—this is a challenge for UKRI as a whole—is that ARPA needs to have the freedom to take the risks over the timescales that will enable these challenges to be tackled.

The opportunity for an ARPA-like model is to identify the challenges. You heard very strongly from the previous panellists about the energy challenge of decarbonisation. Another area is low-cost nuclear power by small modular reactors where, again, there is a challenge. It will take the paymasters—Government and the Treasury—to make the body truly arm's length in a way that it can tackle the challenges over the timescales that are necessary and not micromanage.

Q72 **Chair:** Sir Mark, thank you for that answer, which was very rich with content that we will want to unpack. Let me push you a little on it. I asked you whether the Government are right to create DARPA. Would it be right to infer from your answer that they should make use of the recent institutions that have been created, rather than create something brand new?

Professor Sir Mark Walport: That would be a sensible thing to do. I suppose people might say, "Well, you would say that, wouldn't you?", but UKRI was created to bring together the ecosystem. It would be perfectly capable of running ARPA-like programmes.

I agree with the previous panellists that challenges are appropriate, and it is very easy to identify them.

It is also worth commenting on the scale of DARPA. DARPA is a $3 billion-a-year organisation. What is proposed is a £200 million-a-year organisation over four or five years. As a result, it is not going to be able to tackle the whole range of things and will need to make some choices. They could well be in the energy area. They could be in the health area.

It is also worth remembering that, if you look at the whole edifice of public funding of science and innovation, it has come out of emergencies. In the United States, the UK and Canada, the first world war created the Medical Research Council in its present form and the Department of Scientific and Industrial Research, which you can effectively morph through to UKRI through a series of changes during the past century.

The second world war led Vannevar Bush to write his science report, "The Endless Frontier", which was the creation of the National Science Foundation.

Then, of course, there was the launch of Sputnik 1. The most important influence of DARPA and of that launch was the creation of the doctrine that the United States would want to remain ahead of the game globally in all areas of technology.

Of course, recently, it is fair to say, they have had a fright because they have discovered that they are not ahead in all areas of technology. AI is another obvious area, as are the hypersonic propulsion systems. There are all sorts of things.

Q73 **Chair:** We will delve into this in more detail. We are very grateful for that. Before I turn to my colleagues, let me put the same question to Jo Johnson: are the Government right to be creating this new institution, DARPA?

Jo Johnson: Good morning, Chair. It is great to be back before the Committee, now under your chairmanship, and to be alongside Sir Mark discussing these issues.

Are the Government right? This could be a useful contribution to our overall research and innovation ecosystem, provided it is complementary and supportive of existing institutions rather than destructive in how it is conceived and organised. That is really important.

I believe that we are making rather slow progress in some ways in trying, as Sir Mark put it, to define what the function of DARPA is going to be. We are now well over a year on but are still having some fairly high-level discussions about its exact purpose. That is important.

If we are going to make more rapid progress in bottoming-out this question, we seriously need something that resembles a Green Paper or a White Paper from Government, setting out clearly the purpose of a UK ARPA and how it will relate to existing institutions. We have had some very high-level comments today, but I do not think there has been a seriously argued presentation by Government of exactly how it is going to work and what it is going to do.

On the question of where it sits in relation to UKRI, like Sir Mark, I am arguably parti pris. You might expect me to say, more or less, what Sir Mark did. I do not see any reason why UKRI, as a young organisation, could not quite easily incubate an ARPA-like body in a way that enabled it to do high-risk, high-reward, use-inspired research. It is quite within the existing powers that we have in the Higher Education and Research Act and the Science and Technology Act 1965 to use secondary legislation to set up an additional council within UKRI with a quite distinct remit to the other autonomous research councils and Innovate UK to do these kinds of projects with a far greater degree of autonomy than we are used to. It is possible to do it within UKRI. I worry that, if we set up this new body outside of UKRI entirely, we will inadvertently damage the rest of our very high-performing research system.

We have an impactful research system. We punch well above our weight as a science country when you look at the impact of the work that we undertake around the world. There is a risk that we start fragmenting the coherence of funding and oversight that UKRI was intended to bring to our system if we start creating new bodies left and right that reduce

UKRI's ability to act as an overall strategic guide to where we need to invest more and where we need to increase our capacity and capabilities as a country.

We need to be very careful that we do not inadvertently, in setting up, as Sir Mark said, this relatively small body, do damage to the rest of the system. There is a risk that we impair UKRI's ability to provide that strategic oversight of the UK's research system. We do not have infinite resources as a science funder, as a Government. It is great that we are increasing resources, but we cannot seriously accept that we have so much money washing around our science system that we can accept the risk of quite significant duplication and overlap.

Sir Mark mentioned the industrial strategy challenge fund. This is a £2 billion vehicle, approximately, with many of the missions that you would expect ARPA, when it is eventually formed, to be focusing on, so how are we going to differentiate ARPA's role from those of the much larger missions within the industrial strategy challenge fund in a way that is not confusing and duplicative?

Certainly for the initial period of its existence, it should be incubated within UKRI. If in time it is found that it needs a greater degree of autonomy, fine—it can be spun out as a standalone organisation. We are now more than a year on. It is time to let UKRI use the powers it has to get this thing going quickly.

Let us see whether it can find a clear role and purpose complementary to everything else that UKRI does and get going on it. If we continue down the path we are on, discussing how it relates to existing funding bodies, how it relates to Innovate UK and how it relates to the various health funding through the National Institute for Health Research, what the charitable sector is doing through Wellcome Leap and so on, we might waste another year and a half putting in place mechanisms for legislation and so on.

We have all the tools we need to get it done now. We should get on and do it, and let's have a go at making this a really useful contribution to our research and innovation ecosystem.

Q74 **Chair:** Perhaps, briefly, you might explain the implication of that. Given what you have described—that this new institution, UKRI, is capable of doing what is intended—why do you think the Government believe it is not? Why do you think they have set out an ambition to create this new agency?

Jo Johnson: There is always a desire to set up new bodies and agencies and for them to make their mark. Governments often want to make a mark in legislation. It is a natural instinct. It is not necessarily a disaster if it is set up outside UKRI. It is quite possible to make it work, because we have the tools to make it work well and quickly, within UKRI. There is considerably less risk of creating confusion, duplication and overlapping

areas of responsibility. I am not saying it would not work if you set it up outside UKRI—it could work fine—but it is a riskier proposition and is less likely to be rapidly delivered if we go down that road.

Chair: Thank you. It is fair to note that Sir Mark was indicating assent to your remarks.

Q75 **Dawn Butler:** Thank you very much, Jo and Sir Mark. I am in complete agreement with you, because it seems to me that all the evidence is pointing to the fact that it should be incubated, as you said, Jo, within UKRI.

Let me play devil's advocate a little. There are people who say there are weaknesses in UKRI, which is why ARPA needs to be set up. Sir Mark, what would you say are the weaknesses of UKRI?

Professor Sir Mark Walport: Thank you for the question. I disagree with your assertion. UKRI is still a young organisation. In reality, it is just two and a half years old as a legal entity, and it has had a year in shadow form. One of the things that worries me is the idea that an ARPA would be high risk/high return, where the implication is that UKRI is the opposite of that. That could not be further from the case. Their record of UK Nobel prize winners continues. In your first evidence session, there was discussion about Janelia. Janelia was modelled on the UK's Laboratory of Molecular Biology, which continues to win Nobel prizes.

It is the very nature and strength of UK research that it is high risk, high return and high reward. Richard Jones characterised it rather well when he said that there is more risk taken in discovery research than at the level of innovation, partly because people do not understand it and do not try to micromanage it externally.

Being completely frank with the Committee, one of the challenges for UKRI has been, because it is new and a lot of money is associated with it, that there has been a desire across Government for quite a lot of micromanagement of UKRI's activity. As it matures, it could be more arm's length than it is at the moment. The characteristic of DARPA all along has been empowerment of the programme managers. Good people can make bad organisations work very well, and bad people can wreck perfectly designed organisations.

The real challenge for setting up an ARPA-like organisation is to make sure that you recruit the very best programme managers. Much of what all of the ARPAs have done is engineering. Then you have to empower those people.

The challenge has been creating the environment that will attract the very best people and give them that freedom. That is what they want. In some senses, they want freedom more than money.

Q76 **Dawn Butler:** To complete my devil's advocate circle, I should put that to Jo to find out whether he thinks there are any weaknesses in UKRI.

Jo Johnson: To pay Sir Mark his due, he has done an incredible job in laying the foundations of UKRI since it came into existence and, prior to that, when it was working in shadow form. It is no small feat to make the research councils add up to more than the sum of their parts, which is the mission that UKRI was given. We had a very fragmented and siloed research system with the seven research councils and Innovate UK removed from them.

They have been given greater coherence. They are now working together much more effectively than they did before, to the benefit of interdisciplinary and multidisciplinary research, which is where so much of the great science and innovation is now taking place globally.

It was really important strategically that a body like UKRI came into existence. Of course, it is still a young organisation. I am sure Sir Mark would identify areas where he would wish he was able to have gone further and faster, but great foundations have been laid.

Dawn Butler: I believe we need to have a more intelligent conversation around science and innovation, which may be the missing piece of the puzzle. That would, maybe, reduce the need for people to think about having another organisation to tag on.

I thank you both for your work. I do not know whether you agree with me, but we are lacking that conversation around how we innovate.

Chair: I hope we will be able to contribute to that conversation through our report.

Q77 **Carol Monaghan:** Good morning to Sir Mark and Jo Johnson. It is good to see you both in front of the Committee again.

Sir Mark, I want to come back on a comment you made earlier about wind power. Let me point out that wind power is an extremely reliable source in Scotland. There are differences.

We are getting clear messages from both of you this morning that ARPA should sit within UKRI. However, we have had other evidence to the Committee from, for example, former Science Minister, Lord Willetts, in which he said that ARPA should be distinct from UKRI, and the Campaign for Science and Engineering says there is no obvious place for ARPA in UKRI and that independence is important. Is there a risk in having ARPA within UKRI that we threaten openness and boldness of those carrying out research? Perhaps we could start with Jo Johnson, because he has been quite clear about where it should sit.

Jo Johnson: The research councils, while they are clustered under the UKRI umbrella and their executive chairs sit on a committee that is effective in considering the overall strategic research and innovation landscape in the UK, are, none the less, autonomous within the organisation and are able to reflect and respond to the needs of their various disciplinary communities. I would not be concerned that they are not capable of significant independence within the UKRI structure.

UKRI would, I believe, be well capable of setting up a new body using the secondary powers that the Secretary of State has under law, and to create an even more independent relationship to either the chief executive or the executive committee, if that were desired. I do not think independence is really the issue.

The bigger issue is how we clearly definite its mission so that it is complementary rather than duplicative of other activities, whether through the industrial strategy challenge fund, in Innovate UK or in other bits of our publicly funded research system, or indeed the charitable sector. In your last session you heard from Wellcome Leap, but other bodies are trying to do use-inspired research. We need to ensure that an ARPA is complementary to all of those, because we do not have resources to waste.

Q78 **Carol Monaghan:** If it sits within UKRI, how do we ensure that enough money is available and that funds are distinct from what would be a typical UKRI budget?

Professor Sir Mark Walport: The Act is set up so that Ministers agree the funding that goes to each of the councils within UKRI, so that would be part of the decision-making process.

Q79 **Carol Monaghan:** Can you see that an issue could exist, if we are deciding the funding going to each and if it is sitting within UKRI, of a reduction in funding in the other areas in order to fund ARPA?

Professor Sir Mark Walport: The budget for ARPA has already been identified as £800 million over the next four or five years. That is already identified.

I want to challenge again the openness and boldness points you make. UK Research and Innovation is all about openness and boldness. It is a false dichotomy to think we want an organisation—UKRI—that is closed and cautious, and an ARPA that is open and bold. The very nature of the research that UKRI is funding means that it is bold.

The issue, really, is one of freedom. I hope that, over time, UKRI gains greater freedom. Greater policy stability is needed. To have the best innovation, one needs a decent timescale over which to do it. If you open the oven door every five minutes while the souffle is rising, it will not rise very effectively. That is the case with research and innovation as well.

Q80 **Carol Monaghan:** Jo Johnson, one of the issues you raised in your evidence is that setting up a whole new body could take a long time to complete, bearing in mind the legislative process. How quickly could it be set up if it did not sit within the incubation of UKRI, or how long could it take?

Jo Johnson: Looking at the experience of UKRI, the last research funder that we set up, that got going with a Green Paper in November 2015. It did not receive Royal Assent until April 2017. It operated in shadow form

for a year until the necessary legislation was commenced. It takes a while. If you have to go down the primary legislation route, you are at a minimum looking at 18 months. Maybe it is possible to expedite that, but I would be surprised if you had a functioning organisation within 18 months.

Q81 **Chair:** Would it be possible, Jo, for it to operate in shadow form during that time, or would it need to wait 18 months before it could do any useful work?

Jo Johnson: Sir Mark is more familiar with how UKRI operated in shadow form. Once you get the budget, you are able to get going and make hires, but there is a difference between operating in shadow form and having the full set of powers that you need.

Professor Sir Mark Walport: UKRI only got started in shadow form after the Act was passed into law. It did not happen as a shadow until the legislation had happened.

Q82 **Andrew Griffith:** Thank you both for joining us. You have answered many of my questions, so I will be brief. However, I am interested in exploring more about the operating model. I am not going to put words into your mouth, but I sense you feel that, with greater operational freedom, some of what is being advocated as the benefits of ARPA could be delivered through UKRI. I would like you to agree, disagree or expand upon that.

It would be interesting to hear a little more about paying people, because we clearly want to expand the pool of capability.

Are there merits in a different institution for the purposes of experimenting with the operating model? I can see the efficiency of having everything under one umbrella, and broadly that keeps everything in a point of alignment. Conversely, sometimes it is okay to throw a stone into a pond to see what the ripples cause and whether there could be cross-fertilisation with other areas of UKRI.

Professor Sir Mark Walport: I do not know whether the Committee is aware, but there was a very comprehensive, 634-page, near contemporary history and analysis of ARPA prepared by Richard Barber & Associates in December 1975. It is worth reading. I read all of it when this matter was being discussed earlier.

The overall ingredients for the success of ARPA were summarised at the time as, first: "Strong office directors to develop their separate technical programmes; very high-quality project officers; attraction of recognised external expertise with freedom to have influence; knowledge of the whereabouts of the best ideas, people and organisations in the private and public sectors; developing an organisational setting that solicits and uses contributions, rapidly identifies critical problem area and makes necessary decisions or interventions as needed; delegation of detailed technical administrations and actions in monitoring subordinates." All of

those, frankly, are the features that you need in, for example, Innovate UK and, to a large extent, in research councils. At the end of the day, the quality of the organisation was all about the people in it.

The question is: what can attract the best people to work? One thing I am proud of in the first three years of UK Research and Innovation is that we were able to recruit very high-calibre executive chairs of the councils. A number of people had said before, "Oh, you'll never succeed in doing that." We proved that to be absolutely wrong. The opportunity, therefore, is to spread that throughout the organisation as a whole.

ARPA/DARPA recruited many people from the private sector, and in order to do that they needed two things. First, they needed the freedom to operate. Secondly, they needed a competitive salary.

The challenge for the UK, whether the ARPA organisation is within UKRI or outside, is to create the conditions in the rest of Government that allow an arm's length body to do this at a time when, for perfectly good reasons, salaries are being challenged.

More important than the salaries is the freedom to operate, on which UKRI is going to be critically dependent for its future success. We are getting there, but on those freedoms there is still quite a way to go.

Jo Johnson: The qualities required are going to be hard to secure, certainly at the normal rates of pay that we are used to. Significant flexibility will need to be introduced into the remuneration that we are used to in the publicly funded system. That will be a challenge.

The skillsets are pretty rare: people who are world class at both the blue-skies research and at knowing how to see products develop that are going to be deployable in the existing business world or of use to Government right now. We will be fishing in a relatively small pool of talent. We will have to be flexible in how ARPA is set up in that respect.

I want to touch, if I may, on some of the points that were made earlier in relation to where the organisation could sit outside UKRI. There would be a real risk if it were situated so far away, in another Department or in the Cabinet Office, that it lost all communication with the rest of the research and innovation system. The idea that it could sit and be answerable to some committee of senior Ministers in the Cabinet Office is very risky, because then it becomes completely separated and cut off. It would be an island with no point of connection back into the rest of the research and innovation system. It would be a mistake to set it up so far away in that respect.

Q83 **Graham Stringer:** Professor Walport and Jo, it is good to see you before the Committee. We are looking at ARPA because it is an idea from Dominic Cummings. Did he talk to either of you about his idea for creating a facsimile ARPA?

Jo Johnson: I have had many discussions with him about it, although not recently. I have waded my way through the blogs as well. I am familiar with his thinking, yes.

Professor Sir Mark Walport: I, too, had several discussions with him about it. I have written to him about it. Yes, we have been discussing.

Q84 **Graham Stringer:** That is evidence that he has consulted quite widely, and with at least two of the correct people on that issue.

I tend to agree with the first comments you made, Sir Mark. This is an unusual problem for Government to have £800 million and not be quite sure what to spend it on. If the money is to be put not into UKRI but into some different kind of research and development body, what model would you choose if you had a free hand in that?

Professor Sir Mark Walport: As you heard in the last session—I entirely agree with Mariana and Richard about some of the problems they identified—there is a series of huge technological challenges facing us. It is very important that we do the research and innovation. Of course, Covid-19 has thrown up a whole set of new ones. We have seen laid absolutely bare over the past few months the social determinants of disease and their influence on the outcomes of Covid-19. We have seen the challenges that we need to invest more in public health, which is the insurance policy that helps one to manage the pandemic.

There are the big questions, which can be solved through existing mechanisms for supporting research and innovation. I identified, when I was thinking about ARPA initially, a series of projects that could be considered if you were looking at where you might focus an ARPA—for example, taking a huge, grand challenge, a physiological understanding of human behaviour. Understanding the physiology of human cognition is the greatest scientific challenge that faces us.

In order to solve that problem, you need to solve a whole series of intermediate problems, such as developing artificial general intelligence, developing an autonomous transport system for a big city, creating a digital plan for the UK, greening the planet—how one could improve photosynthesis, improve food and capture CO_2 from the air. Material sciences offer huge possibilities. These are all big challenges. Any one of them could absorb an ARPA of the size of what is proposed.

I would go back to what I said at the beginning, which is that DARPA has been a success because: first, it has had a lot of money; secondly, it has had very good programme managers; and, thirdly, it has had a customer who wants the product.

It is not quite so obvious that ARPA-E is going to be so successful, because it is not quite so clear that the customer is there in the United States.

Any of these needs customers inside Government. That is an area where there has been a push on the procurement side for innovation since I first joined the Council for Science and Technology in 2004. A constant refrain of the Council for Science and Technology was that there needed to be better procurement. The danger is that we see this as a push that will solve a problem, where the pull side is equally important.

Q85 **Graham Stringer:** That is interesting. You have outlined a number of areas that could usefully have a lot of funds devoted to them. The more we know, the more we know we don't know. Should any new ARPA have a single focus? Should Government choose one of those areas and say, "That is the problem we are going to solve," rather than it being more spread out?

Professor Sir Mark Walport: Eight hundred million pounds will not enable one to tackle more than one or two of these problems systematically. Again, one of the dangers in our funding system is that we are always under pressure to salami-slice, so do not tend to fund things as well as we should. That is a constant issue.

We tend to fund for the first five years and somehow think that, after that, the funds will miraculously be found from elsewhere. Unless we take a sustained approach to tackling problems, we will not succeed as well as we could.

Q86 **Graham Stringer:** Is this discussion really recasting the "valley of death" discussion in a different form?

Professor Sir Mark Walport: Partly, that is true. As I said, discovering things is one thing, but it is how you apply them. The market tends to be quite risk-averse. Venture capitalism is not adventure capitalism some of the time.

Q87 **Graham Stringer:** Jo, will you comment on the point about the valley of death problem? From listening to both you and Sir Mark previously, if one wanted to be cynical, one would say, "That's just a bureaucratic response to defend current institutions against a new idea." Sir Mark is already shaking his head. Could you comment on both those things, please?

Jo Johnson: Mr Stringer, it is good to see you again. On the valley of death point, ARPA needs to clarify whether it is addressing the valley of death problem, which is certainly an important one, or whether it is trying to do use-inspired research, which is a very different problem and mission.

My understanding is that it is trying to do use-inspired research—identifying a technology that we know we are going to need but does not exist today, and developing the research that will enable us to create those applications in future. The valley of death is a rather different problem.

One of the first points I was making is that we need to decide quite quickly what ARPA's function is going to be and which of these different sets of problems it is actually going to focus on. The point is that we have other bodies and other funding streams that are focusing on the important valley of death issue, which you mentioned.

On the point of, "This is just a bureaucratic play to defend an existing institutional set-up," you may be right. There may be touches of that. What actually motivates me is the desire to see the best for our science and research system. UKRI has been absolutely pivotal in securing additional resources for science and innovation in the UK. It has provided the Treasury with what it needed: a single point of accountability for our public investment in R&D and innovation. I am concerned that, at the margin, that will be lost if we create a new, big public funding body outside of it that fragments the coherence that UKRI provided to the Treasury—a picture of the value for money that we get from our funding activities.

Professor Sir Mark Walport: The reason I was shaking my head is not that UKRI is some dinosaur that has been there for a million years but that it is a new organisation. It is only two years old. It is far too early to be making judgments about the success or otherwise of UKRI. So far, so good, I would say.

Q88 **Aaron Bell:** Thank you both for your time today. I want to talk about the proposed structure of ARPA in a moment, but do you see a UK ARPA doing something fundamentally and qualitatively different from what we do at the moment, or is it, as currently outlined, going to be more money under a different umbrella? Is that the risk as you see it?

Professor Sir Mark Walport: The answer is that, if it was really to focus on a very big single area, it could well be doing something that is distinctive. The danger is that, if it tried to do all the things I just said, it would do none of them properly. The big opportunity is to make a very serious investment—an £800 million investment—in one challenge area.

If you look at investments in artificial intelligence, for example, £800 million would not be viewed around the world as necessarily a huge investment. Picking one of those and doing it really well—a digital twin of the UK, say—would be an enormous challenge. Otherwise, there is a danger that, if it tries to do everything, it will end up doing nothing well.

Q89 **Aaron Bell:** Jo, do you see a qualitative change with this extra money going into ARPA, or is it just more money under a different umbrella?

Jo Johnson: We do not know yet. To say "high risk, high reward" is not a clear enough mission statement. It is not a clear enough defining purpose. We need to know how it is going to be different from the mission that is funded by the £2 billion industrial strategy challenge fund and how it is going to be different from the nearer-to-market innovation

support provided by Innovate UK and its network of Catapults, for example.

It could well be different. If it has, as Sir Mark says, a very distinct single or dual mission to identify a couple of technologies that we know we are going to need as a society in 10 or 15 years' time but which do not exist today and we could help to create, I agree that that would be qualitatively different.

It is not, at the same time, a million miles away from some of the objectives that are being set out in the industrial strategy challenge fund, such as objectives for driverless cars, zero-carbon flight and other technologies that we know do not exist today but which we want to exist and which we are trying to develop. It is a question of degree.

Q90 **Aaron Bell:** There is, obviously, the mission element to it. Is the internal structure also going to be a qualitative point of difference? If we replicate, more or less, DARPA's structure of programme managers, is that sufficiently different from what has been going on before that it might make a difference to the outcomes?

Jo Johnson: Sir Mark can speak more to how the programme managers work within the industrial strategy challenge fund, but they were meant to have been modelled on the programme directors at ARPA. So they are conceived in the same spirit that is motivating the Government in creating ARPA.

Q91 **Aaron Bell:** Sir Mark, you have set out how important it is that we get the right people to do it. You have mentioned that pay is one part of it, but do you think that ARPA will have sufficient cachet to attract the right project managers and, most importantly, the right director, as it is currently envisaged?

Professor Sir Mark Walport: We have, over time, recruited very good programme managers and project directors for the industrial strategy challenge fund. Initially, it was hard because people did not quite know what this was, but, over time, we are able to recruit very good people. They get frustrated by the lack of freedom, and that is the challenge that has to be created, but it is a challenge that UKRI faces. As I said, we can get good people, but pay does matter.

Q92 **Aaron Bell:** Is primary legislation required to put on a statutory footing the freedom that people would have? Is that a case for taking the primary legislation approach?

Professor Sir Mark Walport: Jo might be better qualified to answer that question, but it is the whole issue of Treasury control. The business cases that are needed by BEIS and the Treasury are quite difficult to write for high-risk, high-return use-inspired research.

Q93 **Aaron Bell:** Do you want to comment on that, Jo?

Jo Johnson: No. I would agree with Sir Mark.

Q94 **Aaron Bell:** Finally, and slightly at a tangent, the Government talk a lot about place. ARPA is more of an idea. It does not need to have much of a physical location. Do you think there is a case, given the levelling-up agenda, for trying to find somewhere outside the golden triangle to locate whatever the physical structures of ARPA look like?

Jo Johnson: There is always a case for looking at where institutions can best be located. I would support a move to rebalance where we are investing public money in science and innovation, provided it is based on excellence and a competitive process. That is obvious.

A more fundamental point is that ARPA, as I understand it, does not conduct its own research but outsources it to where it can best be procured. In terms of its physical imprint, it may not be that substantial as a contribution to the rebalancing of our science budget endeavour. I understand the politics and the need to locate more institutions outside the golden triangle. To the extent that that is helpful, I would be supportive of that.

Professor Sir Mark Walport: I have two comments. The industrial strategy challenge fund is among the most widely distributed national funding we have, with very significant funding in the west midlands, for example. It is very widely distributed.

I reiterate the point Jo just made: the actual organisation itself is a relatively small one—it is where it spends its money that matters.

There is also a potential issue, in that mixed-motive investing often goes wrong. The strength in places fund has been very effective, although it is still in its early days, in its specific mission to spread research and innovation around the UK. DARPA, for example, just looks to see where the best people are and the best possibilities. The truth is that when we have done this through the industrial strategy challenge fund, as Jo said, we have found that expertise is very widely distributed. I am not too worried about that.

If you place too many requirements on the funding and the freedom of the programme managers, you may throw out the baby with the bath water.

Q95 **Chair:** Thank you very much. I have some final questions to ask. The Committee has taken written evidence, as we always do in these inquiries. The written evidence from the University of Oxford contains a striking sentence: "Most current UK funding programmes tend to focus on incremental advancements, and highly ambitious investments are mostly considered too high risk for public funds." Is that an assessment that you would share?

Professor Sir Mark Walport: No, I would not share it at all. Look at the Laboratory for Molecular Biology. Look at the Crick Institute and the Royce Institute. The fellowship programmes that are increasingly being supported by UK Research and Innovation support the most talented

researchers at the very earliest stages of their career. They are all about risk.

Jo Johnson: The peer review system that allocates a significant part of our research system could be seen as overly conservative. I would certainly recognise that. On the other hand, a very significant chunk of our research system is allocated in the form of block grants to universities such as the University of Oxford. If they feel they are not spending that money wisely, we ought to know about it.

Q96 **Chair:** That is an interesting response to an interesting observation. It goes to one of the questions that is hovering around this issue: is the proposal for ARPA/DARPA a critique of the current way in which we fund research, or is it about something completely different—setting new missions and goals? There seems to be something of each around it.

On the point of setting the priorities, Sir Mark has said that the available funding is adequate only for a maximum of two priorities. How would you recommend that those priorities were set? Would they be set by the institution, or should they be—you heard the previous session—set by Government in some way, by a national conversation about what they are, and then given to the institution?

Professor Sir Mark Walport: Let me comment on the first part. On the peer review question, there is a whole question of bureaucracy. In the first session, you asked your witnesses from the United States about this question of peer review. They said that plenty of peer review goes on in DARPA. I agree with Jo's point that the peer review system can sometimes be rather unimaginative. I have joked in the past, albeit a slight joke, that decisions of committees are sometimes made by the least imaginative member. There is a challenge to make sure that peer review works as effectively as possible. In DARPA, all along, the peer review is done by the programme managers and project managers. It comes back to the fact that the review will work most effectively if it is done by the most imaginative people. That is absolutely critical.

Ultimately, the decisions have to be made by Ministers. This is taxpayers' money. If there are to be questions that the new ARPA is going to be permanent, ultimately Ministers will need to agree, but Ministers do not get out of bed thinking, "We must solve this problem." It is part of a conversation. There needs to be a conversation between the research and innovation communities and Ministers. At the end of the day, Ministers will decide.

Q97 **Chair:** Jo Johnson, do you have any comment on the setting of priorities, who should do it and how it should be done?

Jo Johnson: It is inevitable that a programme of this profile and stature would be of great interest to Ministers and that they would want to set the broad missions, and to do so, maybe, after a national conversation.

The only risk is that you see ministerial interests du jour chopping and changing and leading to a certain short-termism in how projects are identified and what the missions are from one moment to the next. That is the only risk I would see, that they end up being the subject of ministerial whims and buffeted around a bit.

Q98 **Chair:** Can you think of any way to make it proof against here-today, gone-tomorrow Ministers?

Jo Johnson: There are clearly mechanisms that you could try to include. You could try to say, "We're going to have a five-yearly process to identify these missions and allocate funds accordingly. They are going to run irrespective of the political cycle and changes of ministerial responsibility." You can try to put in a political brake in that respect.

Q99 **Chair:** Finally, you talked about the delay in setting up this new organisation—there has already been a delay—and you said that it could take 18 months based on your experience of setting up UKRI. If the organisation was set up under the UKRI umbrella, do you have a feeling about how quickly that could be done?

Jo Johnson: You would need to get the secondary legislation—the regulations—through both Houses. Then you would have to hire the director and agree the budget with the Treasury. That could be done in a matter of months, probably three months, if the Government put their mind to it.

Professor Sir Mark Walport: I agree completely. It could be done very straightforwardly. The critical task is hiring the director. At the end of the day, these things are all about the people.

Chair: We are very grateful to both of you for coming back to appear before this Committee, which you have done on many different occasions in the past. It is very good to have you today, and we are very grateful for the clarity of your evidence based on your extensive experience.